

MODELING PROGAMS

THIS DATA SET HAS BEEN RESTORED. ORIGINALLY IT
CONTAINED TWO 9-TRACK, 1600 BPI TAPES WRITTEN IN ASCII.
THERE IS ONE RESTORED TAPE. THE DR TAPE IS A 3480
CARTRIDGE AND THE DS TAPE IS 9-TRACK, 6250 BPI. THE
ORIGINAL D008548 WAS CREATED ON THE MODCOMP IV COMPUTER
AND D000101 WAS CREATED ON THE IBM 3081 COMPUTER AND THEY
WERE RESTORED ON THE MODCOMP CLASSIC II COMPUTER. THE DR
AND DS NUMBERS ALONG WITH THE CORRESPONDING D NUMBERS ARE AS
FOLLOWS:

DR#	DS#	D#	FILES	NSDF ID
DR004300	DS004300	D008548 D018182	1-16 17-20	SEE BELOW PG-12A
FILE	PROGRAM NAME			NSDF ID
1	FIELD/FIELD WITH 7094 JCL			PG-11A
2	ONEMAG WITH IGRF 1965			PG-12E
2	DEKMAG			PG-12D
3	LINTRA PACKAGE WITH 360 JCL			PG-12B
4	SHELLG/FIELDG WITH IGRF 1965 1970			PG-13A
5	SHELLG/FIELDG WITH 7094 JCL			PG-13A
6	INTLEG PACKAGE			PG-13A
7	INTELG PACKAGE WITH 7094 JCL			PG-13A
8	IGRF/SPHRC PACKAGE (OLD VERSION)			PG-14A
9	IGRF/SPHRC PACKAGE WITH 260 JCL			PG-14A
10	INVAR PACKAGE N/NEWMAG WITH 7094 JCL			PG-16A
11	TSFORM/DIPFLD			PG-17A
12	TSFORM/DIPFLD WITH 7094 JCL			PG-17A
13	PFITZER'S B L RETRIEVAL PACKAGE			PG-18A
14	PROGRAM TRAJLST			PG-18B
15	INVARA PACKAGE (B&L) WITH 360 JCL			PG-19A
16	ONEMAG WITH IGRF 1980			PG-12C

STASS' PROGRAMS

PG-12A

PG-12B

THIS CATALOG CONSISTS OF ONE 556 BPI, BCD, tape containing the following
026 punch programs on D-18182 (C-14437):

FILE 1 INVARA PACKAGE

- a. MAIN (INVARA)
- b. INVARA
- c. STARTA
- d. LINESA
- e. INTEGA
- f. CARMELA
- g. CONVRT
- h. INVARA DATA
- i. ALLMAG (SHORT)
- j. ALLMAG (LONG)

FILE 2 GDALMAG PACKAGE

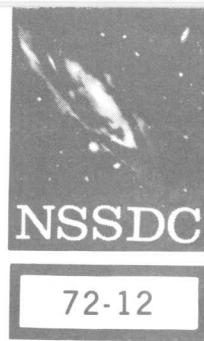
- a. MAIN (GDALMAG)
- b. GDALMAG
- c. ALLMAG (SHORT)
- d. ALLMAG (LONG)

FILE 3 LINTRA PACKAGE

- a. LINTRA
- b. CONVRT
- c. ITERAT
- d. LINTRA DATA

FILE 4 ALLMAG

- a. ALLMAG (SHORT)
- b. ALLMAG (LONG)



ALLMAG, GDALMG, LINTRA:
COMPUTER PROGRAMS
FOR GEOMAGNETIC FIELD
AND FIELD-LINE CALCULATIONS

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NATIONAL SPACE SCIENCE DATA CENTER

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ABSTRACT

A set of computer programs has been developed for the calculation of the geomagnetic field and the tracing of field lines in space. The basic subroutine, geocentric ALLMAG, contains coefficients for seven recently-published field models as built-in data statements. At execution time the user can vary the model and/or the time period simply by changing input parameters. Subroutine GDALMG is adapted for input and output in geodetic coordinates. ALLMAG and GDALMG are equivalent to Cain's FIELD and FIELDG, with the added flexibility of the choice of seven models. LINTRA traces field lines from any point in space to a specified altitude intersect in the same or opposite hemisphere, using any of the models contained in ALLMAG. Input is in either geocentric or geodetic coordinates, and output is returned in both. McIlwain's INVAR package, which calculates B and L, has been adapted to use ALLMAG. All programs are described in detail, and sample calculations are given.

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ATTACHMENTS: PROGRAM LISTINGS AND SAMPLE OUTPUTS

ALLMAG, GDALMG, LINTRA: COMPUTER PROGRAMS FOR GEOMAGNETIC FIELD AND FIELD-LINE CALCULATIONS

1. INTRODUCTION

The proliferation of quantitative geomagnetic field models in the last decade, evidently stimulated by the advent of the space age and the satellite era, has resulted in a confusing abundance of good numerical models that are based on a spherical harmonic expansion of the geomagnetic potential. Most of these models have included first- and occasionally second-order time derivatives of the spherical harmonic coefficients, giving the secular change of the field.

There has been for some time a need for a versatile, unified set of computer routines which would permit the user to choose different models and/or time periods during one execution time, in order to compare the predictions of different models or to compute the value of the field at different time periods.

In the past, when it was desired to perform field calculations with a different model or another time period, it was in many cases necessary (e.g. McIlwain's INVAR) either to replace completely the field-computing routine or to first calculate the coefficients for the new date, punch them onto cards, and then physically insert them into the model deck; this was at best an error-prone and time-consuming procedure, lacking both flexibility and efficiency.

The purpose of our effort was to devise a practical and dependable system by which these shortcomings could be overcome without sacrificing either accuracy or speed. It resulted in the creation of ALLMAG, a program package combining in one operation two previously separate functions, namely the calculation of coefficients for a given model and time period and the computation of the field vector. ALLMAG has the added advantage of incorporating seven widely used field models "under one roof," without having to read in data cards at execution time. These models, all with internal source terms only, are described in the next section. During a single execution one can successively vary either the model or time period, or both.

The spherical harmonic coefficients for the models are stored in data statements in the beginning of the program; in this respect, the code is complete and self-contained. The coefficients are tested for accuracy and renormalized the first time the subroutine is called; updated coefficients are then calculated each time a new model or time period is selected.

All programs are written in FORTRAN IV computer language and card decks are available in either the 029 model IBM keypunch format (EBCDIC) for use with the IBM 360 series machines, or the 026 keypunch format (BCD) for other FORTRAN-compatible computers. An INVAR program (Hassitt and McIlwain, 1967) has been modified slightly so as to accept ALLMAG in place of NEWMAG. It yields identical values of B and L if used with the same model and time period. Sample calculations are given for GDALMG-ALLMAG, LINTRA, and the modified INVAR.

Complete listings are given for all programs except for INVAR (see Hassitt and McIlwain, 1967, for listings) and the long version of ALLMAG (see Cain et al., 1968, for listings of the arithmetic statements of the long version).

2. SELECTION OF MODELS

Seven geomagnetic field models were selected for inclusion into ALLMAG. Table 1 lists these models together with some of their basic characteristics. We included only models for which documentation was readily available through journal publication or otherwise; no preliminary models were included. We concentrated on the most recently-published models, although a few earlier, widely-distributed models were also included so as to enable direct comparisons with earlier subroutines. We did not include the widely-quoted Jensen and Cain model, since it contains no time-derivative terms and gives extremely poor predictions of the present-day field (see Cain and Sweeney, 1970).

Note that Table 1 gives both the epoch and the data range. The term "data range" is used here to denote the time period during which geomagnetic data were obtained to define the model. The "epoch" of a model with secular time-derivative terms is the zero of time from which Δt is calculated in order to add or subtract the time-derivative contribution to the main-field terms. Since in this sense the epoch is simply a numerical constant, it may or may not lie within the data range. All the Cain models, for example, are based on an epoch of 1960, for simplicity, even though the recent POGO models utilize data only from POGO satellites, the first of which was launched in 1965.

It is customary to set the input variable TM equal to the time period for which one wishes to calculate the field. It is generally undesirable, however, to input a time more than a few years away from the data range of a given model, since to do so requires extrapolation well outside the time period over which data was obtained to define the model. Recent studies (Mead, 1972) have shown that such large extrapolations can lead to highly unreliable and often divergent results. If we desire to predict the characteristics of the field in 1973.0, for

example, using a model such as POGO 10/68, whose data range is 1965.8-1967.9, it would be better to choose something like 1969.0 as a time input to the model, rather than 1973.0, which would require linear extrapolation over five years outside its data range. There are two reasons why these large extrapolations are undesirable. First, most models assume that the secular variation is linear, whereas long-term studies (Cain and Hendricks, 1968) clearly show that the secular variations are often highly non-linear and that linear extrapolations many years into the future are unreliable. Secondly, several of the models have used a relatively short time period to determine the secular time derivatives. It appears that data ranges of at least five years are necessary to clearly establish the linear trends.

Since the models contained in ALLMAG include no external sources, they yield very unreliable results beyond geocentric distances of 3-5 earth radii. Strong perturbations (10-100% or more) of the geomagnetic field are present in the outer magnetosphere. These perturbations depend on local time and season as well as solar wind conditions. Some improvement in the accuracy of field predictions at these distances can be obtained by adding the contribution of external sources predicted by a model such as Mead's (1964). An improved model of the external field based on least-squares fits to satellite magnetometer data (Mead and Fairfield, 1971), explicitly incorporating seasonal effects caused by the varying tilt of the dipole with respect to the solar wind, will soon be available.

A few comments on each model are appropriate. Model 1 (GSFC 9/65) was based mostly on surface survey data, with some additional localized satellite data from Vanguard 3 and Alouette. This model, updated to the time period 1965, was incorporated into the NEWMAG subroutine of the INVAR B-L program (Hassitt and McIlwain, 1967). Model 2 (GSFC 12/66) incorporates survey data back to 1900 and is the only model containing second time-derivative terms, thus making a quadratic fit to the secular variation. As such, it is probably the best single model fitting surface data over the period 1900-1965 (Cain and Hendricks, 1968). However, more recent models give better predictions of the current field. Model 3 (POGO 10/68) was the first model to use only satellite data (measurements of field magnitude only; no directional data included). Its data range is very short (2.1 years), and therefore its time derivative terms are rather poorly determined. With this model, the variable TM should probably be limited to the time period 1964-1969. Model 4 (POGO 8/69) is the most recently-published model from the Cain group as of this writing. Model 5 (IGRF) is now internationally-accepted as a reference field to use as a standard whenever comparisons are needed. Since it was derived from the components of many different models, no data range for it is given in Table 1. Model 6 (LME 1965) was used for the preparation of world magnetic charts for the epoch 1965.0 published by the Hydrographic Office of the British Ministry of Defence. The

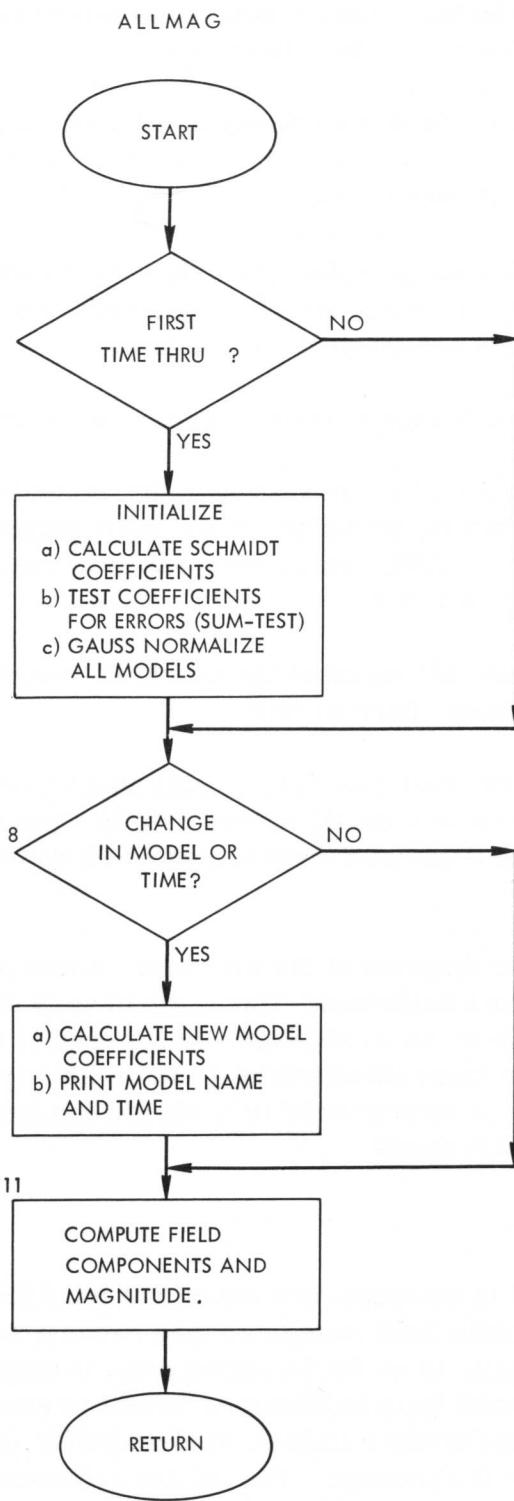


Figure 1. Flow Diagram of ALLMAG

When DEKMAG is called as a subroutine for the first time, a READ sequence is initiated. A deck containing one parameter card plus from one to seven sets of coefficients are to be placed in the card input stream so as to be available when the subroutine is first called. The input stream is as follows:

Card 1: NMODLS (Col. 5), NPRINT (Col. 10)

Deck A: First model to be read in

Deck B: Second model, etc.

The variable NMODLS, an integer from 1 to 7, controls the number of models to be read in. NPRINT controls the amount of information on each model printed in the output stream. If NPRINT = 0, only the label, as read in on the first card of the model deck, and the value of G(2,1), the largest coefficient, is printed out. If NPRINT = 1, the values of all coefficients are written on the output stream.

The decks containing the model coefficients should be in the standard format as distributed by the Cain group at GSFC. The format for each model deck is as follows (see also Cain et al., 1968):

First card: Epoch (Cols. 4-9), Label (Cols. 10-73)

Intermediate cards: N (Cols. 1-3), M (Cols. 4-6), GNM, HNM, GTNM, HTNM, GTTNM, HTTNM (11 Cols. each)

Last card: Zero or blank in Cols. 1-3

The values of the parameters J and K, normally punched in Cols. 1 and 2, respectively, of the first card of the model decks distributed by the Cain group, are assumed by the program to be zero; thus the program assumes that the coefficients are for an oblate earth and are Schmidt-normalized. One should not, therefore, read in the Jensen and Cain coefficients (K = 1) or the Leaton, Malin, and Evans coefficients (J = 1) without modifying the program. Likewise, if DEKMAG is to be used with GDALMG, the branching statements in GDALMG for MODEL = 6 should be modified, unless the Leaton et al. model is to be read in as the sixth model.

The models are assigned a number corresponding to the order in which they appear in the input stream. The integer MODEL in the calling sequence then determines which model is to be used. A STOP command is encountered if MODEL < 1 or MODEL > NMODLS. Each time a new model or new time is selected, a statement is printed in the output stream with the model number,

GDALMG

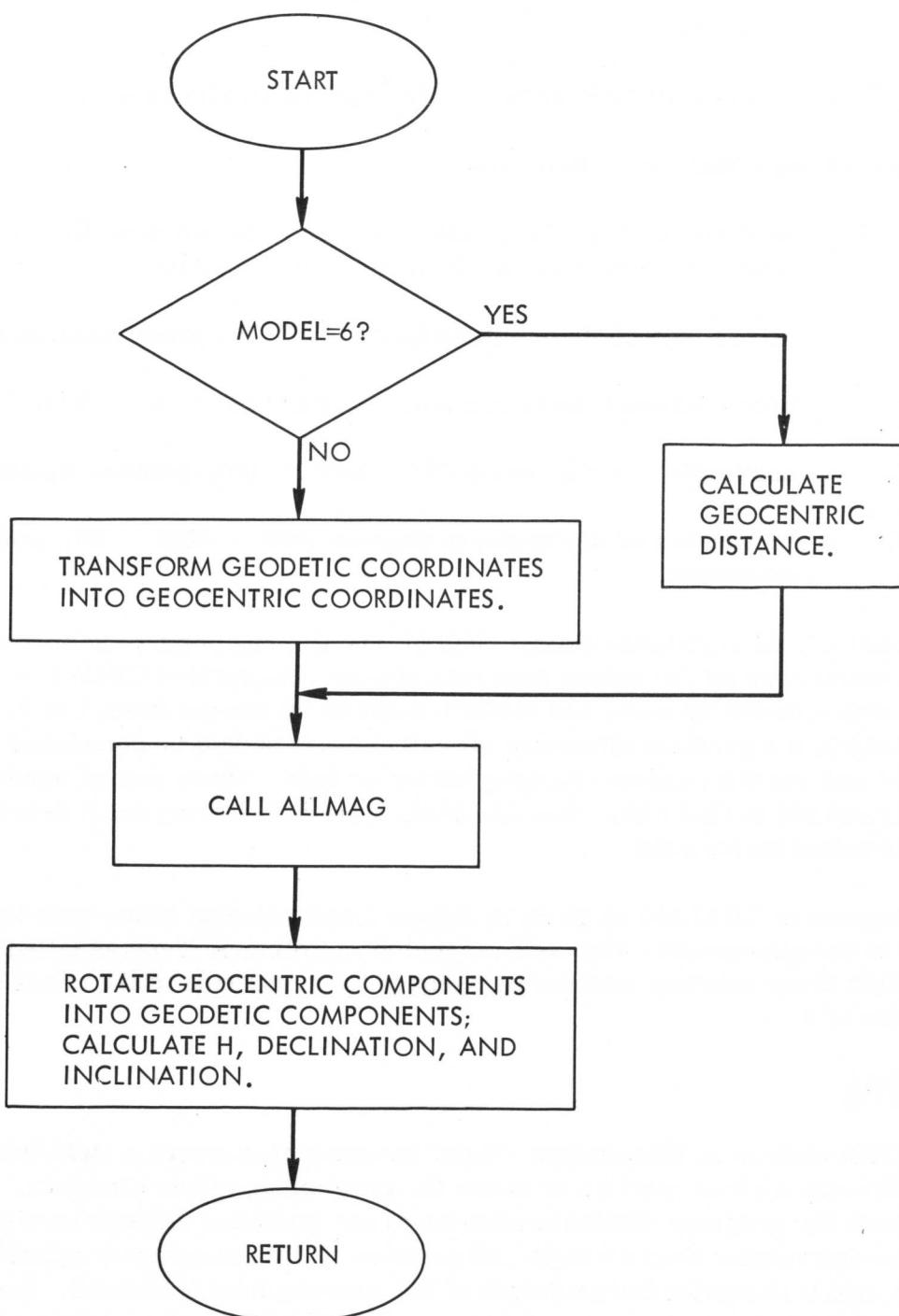


Figure 2. Flow Diagram of GDALMG

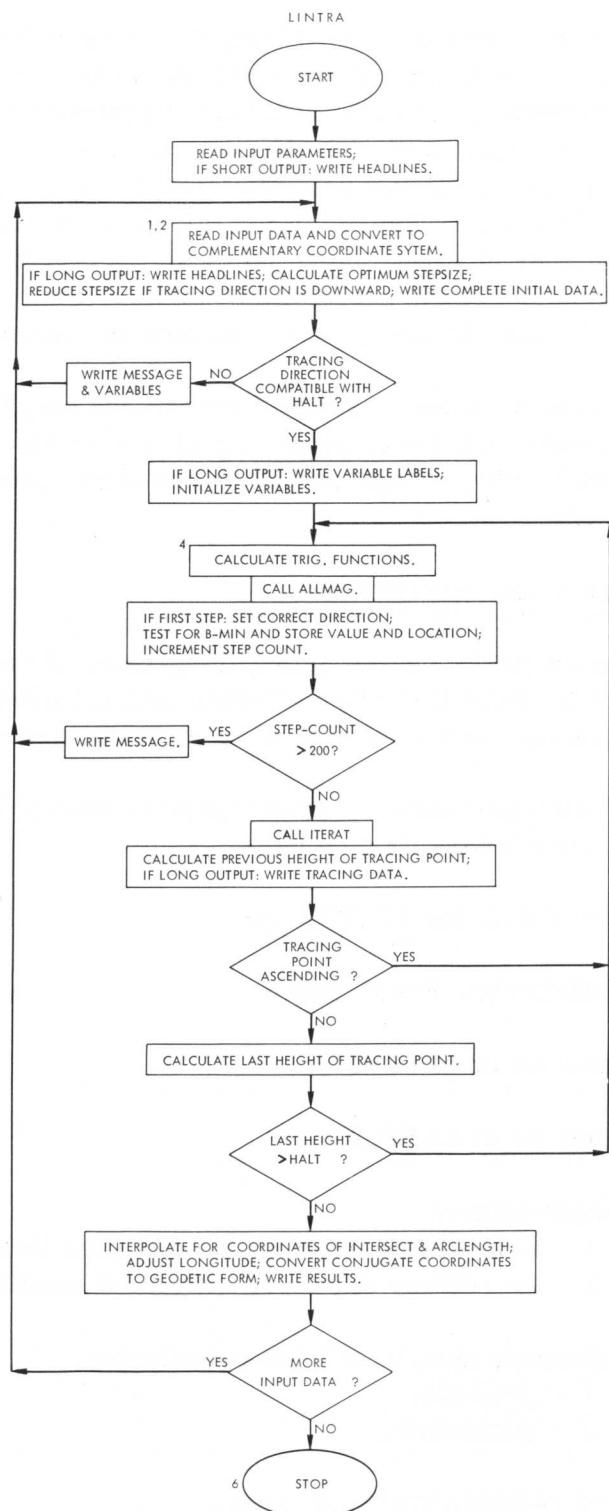


Figure 3. Flow Diagram of LINTRA

If ICOORD = 1:

GDLAT, GLON, ALT : geodetic latitude and east longitude, in degrees, and altitude above geoid, in kilometers;

Or, if ICOORD = 2:

GCLAT, GLON, RKM : geocentric latitude and east longitude, in degrees, and geocentric distance, in kilometers;

DS : integration step size (tracing increment), in kilometers;

(Note: This parameter may be omitted, since the program determines DS unless cards LINTR 132 and 134 are commented out.)

DIR : tracing-direction control:
= $> 0.$: traces towards higher altitudes;
= $< 0.$: traces towards lower altitudes;

HALT : geodetic altitude of desired intersect, in kilometers;

LABEL1, LABEL2 : name of station or designation of origin (starting point).

MODEL, NPRINT, and ICOORD are integers; LABEL1 AND LABEL2 are alphanumeric; all other arguments are floating-point variables. If DIR = -1, and HALT $>$ ALT, the line is not traced.

If long output has been specified (NPRINT = 1), the code will print the following variables for every integration step:

L : current step-count;

DLATP, DLONP : geocentric latitude and longitude of last position (L-1), before iteration, in degrees;

RP, HP : geocentric distance and altitude of last position (L-1), before iteration, in kilometers;

BR, BT, BP : same as in ALLMAG, at last position (L-1);

B : same as in ALLMAG, at last position (L-1).

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APPENDIX A

COMMENTS ON ALLMAG

ALLMAG is the fundamental routine which calculates the three components of the vector field from a spherical harmonic expansion. The relevant mathematical formulation is readily available in, for example, Chapman and Bartels (1940) and Cain et al. (1968), and we shall not repeat it here. We have adhered to Cain's treatment in most respects. ALLMAG is essentially similar in its basic mathematics to Cain's subroutine FIELD, with the following differences in the organization of the program:

1. Any one of seven models may be selected; successive selection of different models is possible.
2. All coefficients for the seven models are built into ALLMAG as DATA statements. ALLMAG contains no READ statements.
3. An internal sum-test is performed on all the coefficients to check for accuracy the first time the subroutine is called, and all coefficients are then converted from Schmidt to Gauss normalization.
4. Different time periods may be selected if desired.
5. A statement indicating the model and time period selected is written on the output stream the first time ALLMAG is called, and each successive time that either MODEL or TM is changed.
6. ALLMAG is completely self-contained if input and output in geocentric coordinates is desired. No other supporting routines are needed.
(GDALMG should be used with ALLMAG if geodetic input and output is desired.)

All coefficients are stored in the DATA statements in their Schmidt-normalized form, since this is the normalization used in all recently-published models (i.e., in Cain's notation, $K = 0$ for all models). All models except Model 6 (Leaton et al., 1965) were derived using an oblate earth ($J = 0$ in Cain's notation). ALLMAG assumes that the appropriate conversion of input quantities into geocentric coordinates has already been performed. See the appendix section on GDALMG for a discussion of these conversions.

These times are averages, obtained from five separate runs of one thousand B calculations each. They include the time used for initialization, coefficient recalculation, and I/O interrupt (but not actual I/O time). The short version times are about a millisecond per call.

The model coefficients are stored as integers rather than real variables. This has two advantages: we found that compilation time is significantly less, and the sum-test, using integer arithmetic, can be exact. The integers are converted to real variables and divided by the appropriate power of 10 (stored as G1 (1, 1), etc.) at the same time as they are converted from Schmidt to Gauss normalization. Equivalence statements are used to conserve storage space.

The EBCDIC short version is supplied in single precision and the EBCDIC long version is supplied in double precision. Only two card changes are necessary to convert either version from single to double precision or vice versa; these changes are indicated in the comment cards. The BCD decks are supplied in single precision only.

APPENDIX B

COMMENTS ON GDALMG

The subroutine GDALMG accepts input in geodetic coordinates, i.e., geodetic latitude and altitude above the geoid. It converts these quantities into geocentric co-latitude and geocentric distance for input into ALLMAG. (Geodetic and geocentric longitude are equivalent.) The geocentric field components obtained from ALLMAG are then converted into geodetic components, and the horizontal component, declination, and inclination are calculated.

The geometry is shown in Figure 4, where the earth is depicted as a grossly exaggerated ellipsoid. The altitude \underline{h} is measured along a plumb line perpendicular to the geoid; and the geodetic latitude λ is measured at the intersection of the plumb line with the equatorial plane.

The reference geoid is that adopted by the International Astronomical Union in 1964. The two parameters defining this geoid are

$$a = 6378.16 \text{ km}$$

$$f = \frac{a - b}{a} = \frac{1}{298.25}$$

where a is the equatorial radius, b is the polar radius, and f is the flattening factor. From these parameters we can derive the following quantities:

$$b = 6356.7747 \text{ km}$$

$$a^2/b^2 = 1/(1-f)^2 = 1.00673966$$

$$e^2 = a^2/b^2 - 1 = 0.00673966$$

where e is the so-called second eccentricity. The geocentric latitude at the surface of the geoid β is related to the geodetic latitude by

$$\tan \beta = \frac{b^2}{a^2} \tan \lambda$$

from which

$$\sin \beta = \sin \lambda / \left(\sin^2 \lambda + \frac{a^4}{b^4} \cos^2 \lambda \right)^{\frac{1}{2}}$$

The geocentric distance to the geoid, ρ , is given by

$$\rho = a / (1 + e^2 \sin^2 \beta)^{\frac{1}{2}}$$

The coordinates (x, y) of the space point P are then given by

$$x = \rho \cos \beta + h \cos \lambda$$

$$y = \rho \sin \beta + h \sin \lambda$$

and thus the geocentric distance R and colatitude θ are

$$R = (x^2 + y^2)^{\frac{1}{2}}$$

$$\theta = \cos^{-1}(y/R)$$

The small angle δ at the space point between the downward vertical and the geocentric direction is given by

$$\delta = \theta + \lambda - 90^\circ$$

which is positive for positive latitudes and negative for negative latitudes. Thus

$$\sin \delta = \sin \theta \sin \lambda - \cos \theta \cos \lambda$$

$$\cos \delta = \cos \theta \sin \lambda + \sin \theta \cos \lambda$$

All of the above equations are exact for any altitude and an ellipsoid of any eccentricity.

The geodetic field components X (northward), Y (eastward), and Z (downward vertical) are related to the geocentric components B_r , B_θ , and B_ϕ approximately by

APPENDIX C

COMMENTS ON LINTRA

Field-line tracing routines are useful in a number of applications: for example, in locating the position of conjugate points, in determining mirror point locations for particles at a given position with a given pitch angle, in calculating the value of the second adiabatic invariant prior to calculating the McIlwain L-parameter, in ascertaining the topology of the magnetosphere, etc. Conceptually, the process is straightforward: given a point in space and a magnetic field model, we wish to trace a line passing through that point which is everywhere parallel to the local field direction as determined by the model. The brute-force technique is to approximate the line by a series of short, straight line segments; each segment is parallel to the local field direction only at one end. Then at the other end of the segment, another straight line segment is constructed parallel to the field at that point. The true curve is approximated by making the segments as short as is required to achieve the desired accuracy. Such a technique is usually time-consuming because of the necessity of keeping each segment short in order to approximate the true curve.

A much more satisfactory approach is to solve the differential equations defining a field line. In cartesian coordinates these are

$$dx/ds = B_x/B$$

$$dy/ds = B_y/B$$

$$dz/ds = B_z/B$$

where ds is the infinitesimal arc length along the line.

In spherical coordinates these equations become

$$dr/ds = B_r/B$$

$$d\theta/ds = (1/r) (B_\theta/B)$$

$$d\phi/ds = (1/r \sin \theta) (B_\phi/B)$$

The LINTRA line-tracing routine integrates these equations with the aid of subroutine ITERAT, using an Adams 4-point integration formula. Since each

the opposite hemisphere in less than 200 steps, yet small enough to insure high accuracy. We have found that if high accuracy is not required, DS can be multiplied by factors of 2 to 5, thus saving significant amounts of computer time. If desired, the user can input the step size, removing or commenting out cards LINTR 130-134.

If one wishes to trace a line initially towards the earth's surface ($\text{DIR} < 0$), a shorter step size is usually desirable. In this case the empirical formula is modified so that DS is no greater than $(\text{ALT}-\text{HALT})/20$, where ALT is the initial altitude and HALT is the final desired altitude.

The old concept of a user-controlled tracing direction has not been changed. However, the range of applicability of new LINTRA was expanded so as to include intersects in the opposite hemisphere which were formerly excluded, namely intersects that have a higher altitude than that of the origin.

In its present form, the program bypasses an intersect in the same hemisphere that lies above the initial point ($\text{HALT} > \text{ALT}$). But this bypass can be removed by commenting out card LINTR 200 from the deck. If the bypass is removed, and if the desired intersect lies close to the initial point, especially when large L-values are involved (high latitudes), it is necessary to override the internally calculated step size and input a step size small enough for effective tracing, that is, no larger than $0.1 \times (\text{HALT}-\text{ALT})$.

Tracing is terminated whenever the altitude of the point on the field line becomes equal to or less than HALT (the specified altitude for the intersect). When this point is reached, the latitude and longitude at the conjugate intersect altitude h_i ($= \text{HALT}$) are determined by a quadratic interpolation formula. If λ_1 , λ_2 , and λ_3 are successive values of the latitude at altitudes h_1 , h_2 , and h_3 , which bracket the desired intersect altitude h_i , then the latitude at h_i is given by

$$\lambda_i = \frac{(h_2 - h_3)(h_i - h_2)(h_i - h_3)\lambda_1 + (h_3 - h_1)(h_i - h_3)(h_i - h_1)\lambda_2 + (h_1 - h_2)(h_i - h_1)(h_i - h_2)\lambda_3}{(h_1 - h_2)(h_i - h_3)(h_2 - h_3)}$$

The interpolated longitude is given by a similar formula.

Finally, in regard to use and results it should be noted that:

1. Tracing accuracy improves only slightly with decreasing integration step size while running-time increases disproportionately; therefore, the calculated step sizes are a good compromise.

APPENDIX D

USE OF ALLMAG WITH INVAR

For the benefit of the numerous users of McIlwain's INVAR program, which calculates the magnetic parameter L, we have replaced subroutine NEWMAG (corresponding to the old MAGNET) with ALLMAG and named the modified deck "INVARA" (for INVAR-ALLMAG). Although very minor changes were made in three subroutines only, the letter A was added to the end of the name of all programs in the deck to differentiate it from the standard versions. The routines INVAR, START, and LINES were modified. Their input-output arguments were implemented to carry the input parameters "MODEL" and "TM" needed by ALLMAG, while statements number 28-36 and 64-74 were added to START and statements 112-122 to LINES, in order to produce the appropriate calling sequence for ALLMAG. Finally, a main program was constructed to read sample input points in either geocentric or geodetic coordinates, convert to the opposite coordinate system, call INVARA, and print results. The subroutine CONVRT (see LINTRA appendix) was added to the package to perform the conversions required by the main program.

```

SUBROUTINE ALLMAG(MODEL,TM,RKM,ST,CT,SPH,CPH,BR,BT,BP,B) ALMGS002
C ***** GEOCENTRIC VERSION OF GEOMAGNETIC FIELD ROUTINE ALMGS004
C ***** SINGLE PRECISION DECK FOR IBM 360 MACHINES (EBCDIC, 029 PUNCH) ALMGS006
C ***** SHORT DECK, USES SUBSCRIPTED VARIABLES AND DO LOOPS ALMGS008
C ***** EXECUTION TIME PER CALL 3 TIMES GREATER THAN LONG DECK ALMGS010
C ***** PROGRAM DESIGNED AND TESTED BY E G STASSINOPoulos AND G D MEAD, ALMGS012
C ***** CODE 641, NASA GODDARD SPACE FLT CTR, GREENBELT, MD 20771 ALMGS014
C ***** INPUT: MODEL CHOICE OF 7 MODELS - SEE BELOW ALMGS016
C ***** RKM GEOCENTRIC DISTANCE IN KILOMETERS ALMGS018
C ***** TM TIME IN YEARS FOR DESIRED FIELD ALMGS020
C ***** ST,CT SIN & COS OF GEOCENTRIC COLATITUDE ALMGS022
C ***** SPH,CPH SIN & COS OF EAST LONGITUDE ALMGS024
C ***** OUTPUT: BR,BT,BP GEOCENTRIC FIELD COMPONENTS IN GAUSS ALMGS026
C ***** B FIELD MAGNITUDE IN GAUSS ALMGS028
C ***** NOTE: FOR GREATEST EFFICIENCY, COMPLETE ALL CALCULATIONS WITH ALMGS030
C ONE MODEL AND ONE TIME BEFORE CHANGING MODELS OR TIME. ALMGS032
C ***** FOR DOUBLE PRECISION ADD THE FOLLOWING CARD ALMGS034
C IMPLICIT REAL*8(A-H,O-Z) ALMGS036
C ***** SEE END OF DECK FOR ONE MORE CHANGE ALMGS038
REAL*8 LABEL(4,7) / 'HENDRICKS&CAIN 99-TERM GSFC 9/65 CAIN ET.AL. ALMGS040
A 120-TERM GSFC 12/66 CAIN&LANGEL 143-TERM POGO 10/68 CAIN&SWEEENEY ALMGS042
B120-TERM POGO 8/69 IGRF 1965.0 80-TERM 10/68 LEATON MALIN EVALMGS044
CANS 80-TERM 1965 HURWITZ US C&GS 168-TERM 1970'/
DIMENSION T0(7),NMX(7),ISUM(7,3),G(13,13) ALMGS046
DATA T0/4*1960.,2*1965.,1970./,NMX/10,11,12,11,9,9,13/ ALMGS048
INTEGER LSUM(7,3)/-1646106,-1795169,-1865298,-1777057,-158472, ALMGS052
A-156856,-2191704,-62661,-96778,-181519,-83555,-9569,-9599, ALMGS054
B-8593,1,-10618,5*1/ ALMGS056
INTEGER*4 G1(13,13),GT1(13,13),GTT1(13,13),G2(13,13),GT2(13,13), ALMGS058
1 GTT2(13,13),G3(13,13),GT3(13,13),GTT3(13,13),G4(13,13), ALMGS060
2 GT4(13,13),GT5(13,13),G5(13,13),GT6(13,13),G6(13,13), ALMGS062
3 GT7(13,13),G7(13,13),GT8(13,13),G8(13,13),GT9(13,13),G9(13,13) ALMGS064
4 ,LG(13,13,7),LGT(13,13,7),LGTT(13,13,7) ALMGS066
REAL*4 GG(13,13,7),GGT(13,13,7),GGTT(13,13,7),SHMIT(13,13) ALMGS068
EQUIVALENCE (G1(1),GG(1),LG(1)), (GT1(1),GGT(1),LGT(1)), ALMGS070
A (GTT1(1),GGTT(1),LGTT(1)), ALMGS072
B (G2(1),LG(1,1,2)), (GT2(1),LGT(1,1,2)), (GTT2(1),LGTT(1,1,2)), ALMGS074
C (G3(1),LG(1,1,3)), (GT3(1),LGT(1,1,3)), (GTT3(1),LGTT(1,1,3)), ALMGS076
D (G4(1),LG(1,1,4)), (GT4(1),LGT(1,1,4)), (GTT4(1),LGTT(1,1,4)), ALMGS078
E (G5(1),LG(1,1,5)), (GT5(1),LGT(1,1,5)), (GTT5(1),LGTT(1,1,5)), ALMGS080
F (G6(1),LG(1,1,6)), (GT6(1),LGT(1,1,6)), (GTT6(1),LGTT(1,1,6)), ALMGS082
G (G7(1),LG(1,1,7)), (GT7(1),LGT(1,1,7)), (GTT7(1),LGTT(1,1,7)) ALMGS084
C ***** THE FOLLOWING DATA CARDS CONTAIN THE FIELD COEFFICIENTS ALMGS086
C ***** FOR THE FOLLOWING SEVEN MODELS: ALMGS088
C ***** G1,GT1: HENDRICKS & CAIN 99-TERM GSFC 9/65 EPOCH 1960. ALMGS090
C ***** G2,GT2,GTT2: CAIN ET. AL. 120-TERM GSFC 12/66 EPOCH 1960. ALMGS092
C ***** G3,GT3: CAIN & LANGEL 143-TERM POGO 10/68 EPOCH 1960. ALMGS094
C ***** G4,GT4: CAIN & SWEENEY 120-TERM POGO 8/69 EPOCH 1960. ALMGS096
C ***** G5,GT5: IGRF 1965.0 80-TERM 10/68 EPOCH 1965. ALMGS098
C ***** G6,GT6: LEATON MALIN & EVANS 1965 80-TERM EPOCH 1965. ALMGS100
C ***** FOR MODEL 6 (LME 1965) SET RKM = 6371.2 + ALTITUDE ALMGS102
C ***** G7,GT7: HURWITZ US COAST & GEODETIC S. 168-TERM EPOCH 1970. ALMGS104
DATA G1 / 10, -304249,-15361,13009,9576,-2277,498,709,48,99,3*0, ALMGS106
A 57748,-21616,30002,-19870,8028,3595,607,-572,67,29,3*0,-19498, ALMGS108
B 2043,15853,12904,5026,2313,45,56,-88,74,3*0,-4310,2308,-1300,8712 ALMGS110
C ,-3940,-312,-2417,75,-138,-156,3*0,1520,-2684,29,-2505,2714, ALMGS112
D -1573,-12,-244,-33,114,3*0,86,1212,-1160,-1104,799,-652,5,-15,71, ALMGS114
E 111,3*0,-119,1028,609,-272,-124,-116,-1091,141,-56,10,3*0,-540, ALMGS116
F -244,-91,22,276,-211,-201,58,117,4*0,69,-122,58,-170,26,236,-25, ALMGS118
G -160,64,16,3*0,-220,156,51,-35,-18,96,121,2,-25,15,42*0 / ALMGS120

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I 1003,150,-1142,-118,58,38,-26,27,-8,-8,2*0,-684,-2832,792,84, ALMGS242
J -536,-27,235,72,33,-46,17,2*0,449,-96,177,327,102,-326,128,86,83,ALMGS244
K -9,-87,2*0,369,564,-109,-205,834,-108,-277,84,42,-37,-12,2*0,234,ALMGS246
L 401,-424,63,-503,504,8,-57,0,-3,-33,2*0,-65,-238,249,-170,234, ALMGS248
M -259,-130,101,49,-48,-33,2*0,-168,-114,58,123,94,40,60,-140,73, ALMGS250
N 54,-21,2*0,1,39,-106,-9,-49,56,-67,-8,-148,-13,27,2*0,48,42,17, ALMGS252
O -41,-22,21,1,-113,16,33,49,2*0,-14,-37,51,-2,4,-19,7,40,-53,31, ALMGS254
P -75,28*0/
    DATA GTT4 /1,168*0/
    DATA G5 / 1, -30339,-1654,1297,958,-223,47,71,10,4*0,5758,-2123, ALMGS260
A 2994,-2036,805,357,60,-54,9,4*0,-2006,130,1567,1289,492,246,4,0, ALMGS262
B -3,4*0,-403,242,-176,843,-392,-26,-229,12,-12,4*0,149,-280,8,-265ALMGS264
C ,256,-161,3,-25,-4,4*0,16,125,-123,-107,77,-51,-4,-9,7,4*0,-14, ALMGS266
D 106,68,-32,-10,-13,-112,13,-5,4*0,-57,-27,-8,9,23,-19,-17,-2,12, ALMGS268
E 4*0,3,-13,5,-17,4,22,-3,-16,6,56*0/
    DATA GT5 / 10, 153,-244,2,-7,19,-1,-5,1,4*0,-23,87,3,-108,2,11,-3,ALMGS272
F -3,4,4*0,-118,-167,-16,7,-30,29,11,-7,6,4*0,42,7,-77,-38,-1,6,19,ALMGS274
G -5,5*0,-1,16,29,-42,-21,0,-4,3,5*0,23,17,-24,8,-3,13,-4,0,-1,4*0,ALMGS276
H -9,-4,20,-11,1,9,-2,-2,3,4*0,-11,3,4,2,4,2,3,-6,-3,4*0,1,-2,-3,-2,ALMGS278
I -3,-4,-3,-3,-5,56*0/
    DATA GTT5 /1,168*0/
    DATA G6 / 1, -30375,-1648,1164,930,-179,42,77,11,4*0,5769,-2087, ALMGS284
A 2954,-2033,811,357,55,-56,23,4*0,-1995,116,1579,1299,490,248,12, ALMGS286
B 8,-6,4*0,-389,230,-141,880,-402,-20,-239,5,-17,4*0,142,-276,5, ALMGS288
C -264,262,-171,16,-35,5,4*0,30,135,-123,-100,84,-64,8,-16,20,4*0, ALMGS290
D -18,101,60,-32,-27,-12,-110,9,-1,4*0,-47,-35,-9,2,27,-17,-24,2, ALMGS292
E 12,4*0,5,-7,3,-20,8,26,10,-12,7,56*0/
    DATA GT6 / 10, 155,-266,0,6,8,7*0,6,83,-13,-95,10,4,-5,6*0,-114, ALMGS296
F -182,13,-19,-22,16,18,6*0,32,16,-85,-6,2,-3,14,6*0,30,-7,27,-27, ALMGS298
G -30,-11,6,6*0,19,23,-18,14,5,17,2,6*0,-22,2,9,-21,-1,-2,-22,84*0/ALMGS300
    DATA GTT6 /1,168*0/
    DATA G7/10,-302059,-17917,12899,9475,-2145,460,734,121,107,-39,16,ALMGS304
A -4,57446,-20664,29971,-20708,8009,3595,651,-546,77,57,-26,-31,30,ALMGS306
B -20582,430,16086,12760,4579,2490,95,46,-32,23,7,-36,5,-3699,2456,ALMGS308
C -1880,8334,-3960,-290,-2188,175,-124,-110,-19,37,-3,1617,-2758, ALMGS310
D 185,-2788,2436,-1669,20,-210,-44,131,-15,-3,-13,157,1420,-1310, ALMGS312
E -911,808,-582,-22,-32,45,33,74,-6,4,-171,1146,625,-323,-78,38, ALMGS314
F -1125,143,34,2,46,-8,-14,-666,-265,-34,81,209,-240,-186,41,125, ALMGS316
G 15,6,1,-12,121,-160,22,-176,46,189,-46,-187,94,9,-8,2,-12,-174, ALMGS318
H 163,14,-27,-32,80,137,-4,-14,-4,22,-24,-1,27,19,0,35,-45,22,-31, ALMGS320
I 56,-1,-63,14,4,10,-2,26,-26,-9,21,-1,18,-14,-28,-17,-14,6,-4,-3, ALMGS322
J 4,9,-1,-10,26,-32,13,-6,-19,7,19,12/
    DATA GT7/10,231,-244,-19,-7,12,-7,0,3,4*0,-46,112,-1,-90,-6,7,6, ALMGS326
K -3,3,4*0,-104,-166,40,-20,-36,12,14,3,4,4*0,72,21,-52,-54,-11,0, ALMGS328
L 17,6,1,4*0,22,-5,14,-24,-23,-15,6,3,-1,4*0,1,25,-14,9,1,11,-3,2, ALMGS330
M -3,4*0,-5,11,2,-3,7,22,-5,1,9,4*0,-17,-3,7,1,-2,-3,-2,-1,-2,4*0, ALMGS332
N 2,-6,-3,-4,1,-2,-2,-1,6,56*0/
    DATA GTT7 /1,168*0/
    DATA SHMIT(1,1) / 0.0 /, TMOLD / 0.0 /, MODOLD / 0 /
C ***** SUBSCRIPTED DO-LOOP VERSION BEGINS HERE
    DIMENSION CONST(13,13),FN(13),FM(13) ALMGS342
    DIMENSION P(13,13),DP(13,13),SP(13),CP(13) ALMGS344
    DATA P(1,1),CP(1),DP(1,1),SP(1) / 2*1.,2*0. / ALMGS346
C ***** BEGIN PROGRAM
    IF(SHMIT(1,1).EQ.-1.) GO TO 8 ALMGS350
C ***** INITIALIZE * ONCE ONLY, FIRST TIME SUBROUTINE IS CALLED
    SHMIT(1,1)=-1. ALMGS352
    DO 18 N=1,13 ALMGS354
    FN(N)=N ALMGS356
    DO 18 M=1,13 ALMGS358
    ALMGS360

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AR=AOR*AR          ALMGS482
DO 17 M=1,N        ALMGS484
IF(M.EQ.N) GO TO 13 ALMGS486
P(N,M)=CT*P(N-1,M)-CONST(N,M)*P(N-2,M) ALMGS488
DP(N,M)=CT*DP(N-1,M)-ST*P(N-1,M)-CONST(N,M)*DP(N-2,M) ALMGS490
GO TO 14          ALMGS492
13 P(N,N)=ST*P(N-1,N-1) ALMGS494
DP(N,N)=ST*DP(N-1,N-1)+CT*P(N-1,N-1) ALMGS496
14 PAR=P(N,M)*AR    ALMGS498
IF(M.EQ.1) GO TO 15 ALMGS500
TEMP=G(N,M)*CP(M)+G(M-1,N)*SP(M) ALMGS502
BP=BP-(G(N,M)*SP(M)-G(M-1,N)*CP(M))*FM(M)*PAR ALMGS504
GO TO 16          ALMGS506
15 TEMP = G(N,M)   ALMGS508
16 BR=BR-TEMP*FN(N)*PAR ALMGS510
17 BT=BT+TEMP*DP(N,M)*AR ALMGS512
1  BR = BR / 100000. ALMGS514
BT = BT / 100000. ALMGS516
BP = BP / ST / 100000. ALMGS518
B = SQRT(BR*BR+BT*BT+BP*BP ) ALMGS520
C FOR DOUBLE PRECISION REPLACE PRECEDING CARD WITH FOLLOWING CARD ALMGS522
C B = DSQRT(BR*BR+BT*BT+BP*BP ) ALMGS524
C THIS AND THE IMPLICIT REAL*8 CARD ARE THE ONLY TWO CHANGES NEEDED. ALMGS526
  RETURN          ALMGS528
  END             ALMGS530

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0265 CARDS

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      WRITE(6,21) K,(LABEL(I,K),I=1,8) DEKMG122
21 FORMAT('0 MODEL NUMBER' I3,5X,8A8) DEKMG124
      MAXN=0 DEKMG126
5   READ (5,6) N,M,GNM,HNM,GTNM,HTNM,GTTNM,HTTNM DEKMG128
6   FORMAT (2I3,6F11.4) DEKMG130
      IF (N.LE.0) GOTO7 DEKMG132
      IF(NPRINT.EQ.1) WRITE(6,6)N,M,GNM,HNM,GTNM,HTNM,GTTNM,HTTNM DEKMG134
      MAXN=(MAX0(N,MAXN)) DEKMG136
      GG(N,M,K) = GNM DEKMG138
      GGT(N,M,K) = GTNM DEKMG140
      GTT(N,M,K) = GTTNM DEKMG142
      IF (M.EQ.1) GOTO5 DEKMG144
      GG(M-1,N,K) = HNM DEKMG146
      GGT(M-1,N,K) = HTNM DEKMG148
      GTT(M-1,N,K) = HTTNM DEKMG150
      GO TO 5 DEKMG152
7 CONTINUE DEKMG154
      IF(NPRINT.EQ.0) WRITE(6,22) GG(2,1,K)
22 FORMAT(' G(2,1) =' F9.1) DEKMG156
      NMX(K) = MAXN DEKMG158
      T0(K) = TZ DEKMG160
      DO 3 N=1,MAXN DEKMG162
      DO 3 M=1,MAXN DEKMG164
      GG(N,M,K) = GG(N,M,K) * SHMIT(N,M) DEKMG166
      GGT(N,M,K) = GGT(N,M,K) * SHMIT(N,M) DEKMG168
      GTT(N,M,K) = GTT(N,M,K) * SHMIT(N,M) DEKMG170
3   IF((MODEL.EQ.MODOLD).AND.(TM.EQ.TMOLD)) GO TO 11 DEKMG172
8   IF((MODEL.EQ.MODOLD).AND.(TM.EQ.TMOLD)) GO TO 11 DEKMG174
C **** NOTE WRITE STATEMENT - NEW MODEL OR NEW TIME DEKMG176
      PRINT 9, MODEL,(LABEL(I,MODEL),I=1,8),TM DEKMG178
9   FORMAT('0 MODEL USED IS NUMBER' I2,2X,8A8,' FOR TM =' ,F9.3/) DEKMG180
      IF(MODEL.LT.1.OR.MODEL.GT.NMODLS) STOP DEKMG182
      MODOLD=MODEL DEKMG184
      TMOLD=TM DEKMG186
      NMAX=NMX(MODEL) DEKMG188
      T=TM-T0(MODEL) DEKMG190
      DO 10 N=1,NMAX DEKMG192
      DO 10 M=1,NMAX DEKMG194
10  G(N,M)=GG(N,M,MODEL)+T*(GGT(N,M,MODEL)+GTT(N,M,MODEL)*T) DEKMG196
C **** CALCULATION USUALLY BEGINS HERE DEKMG198
11  SP(2)=SPH DEKMG200
      CP(2)=CPH DEKMG202
      DO 12 M=3,NMAX DEKMG204
      SP(M)=SP(2)*CP(M-1)+CP(2)*SP(M-1) DEKMG206
12  CP(M)=CP(2)*CP(M-1)-SP(2)*SP(M-1) DEKMG208
      AOR=6371.2/RKM DEKMG210
      AR=AOR**2 DEKMG212
      BR=0.0 DEKMG214
      BT=0.0 DEKMG216
      BP=0.0 DEKMG218
      DO 17 N=2,NMAX DEKMG220
      AR=AOR*AR DEKMG222
      DO 17 M=1,N DEKMG224
      IF(M.EQ.N) GO TO 13 DEKMG226
      P(N,M)=CT*P(N-1,M)-CONST(N,M)*P(N-2,M) DEKMG228
      DP(N,M)=CT*DP(N-1,M)-ST*P(N-1,M)-CONST(N,M)*DP(N-2,M) DEKMG230
      GO TO 14 DEKMG232
13  P(N,N)=ST*P(N-1,N-1) DEKMG234
      DP(N,N)=ST*DP(N-1,N-1)+CT*P(N-1,N-1) DEKMG236
14  PAR=P(N,M)*AR DEKMG238
      IF(M.EQ.1) GO TO 15 DEKMG240

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SUBROUTINE ONEMAG(TM,RKM,ST,CT,SPH,CPH,BR,BT,BP,B)          ONEMG002
C ***** THIS VERSION CONTAINS ONE MODEL ONLY - IGRF 1965.0    ONEMG004
C ***** GEOCENTRIC VERSION OF GEOMAGNETIC FIELD ROUTINE    ONEMG006
C ***** SINGLE PRECISION DECK FOR IBM 360 MACHINES (EBCDIC, 029 PUNCH) ONEMG008
C ***** SHORT DECK, USES SUBSCRIPTED VARIABLES AND DO LOOPS    ONEMG010
C ***** PROGRAM DESIGNED AND TESTED BY G D MEAD, CODE 641, GSFC   ONEMG012
C ***** INPUT: TM      TIME IN YEARS FOR DESIRED FIELD        ONEMG014
C ***** RKM      GEOCENTRIC DISTANCE IN KILOMETERS           ONEMG016
C ***** ST,CT     SIN & COS OF GEOCENTRIC COLATITUDE         ONEMG018
C ***** SPH,CPH   SIN & COS OF EAST LONGITUDE                ONEMG020
C ***** OUTPUT: BR,BT,BP  GEOCENTRIC FIELD COMPONENTS IN GAUSS  ONEMG022
C ***** B        FIELD MAGNITUDE IN GAUSS                      ONEMG024
C ***** FOR DOUBLE PRECISION ADD THE FOLLOWING CARD          ONEMG026
C     IMPLICIT REAL*8(A-H,O-Z)                                ONEMG028
C ***** SEE END OF DECK FOR ONE MORE CHANGE                 ONEMG030
C
C DIMENSION LG(13,13),LGT(13,13),G(13,13),GG(13,13),GGT(13,13),    ONEMG032
C 1 SHMIT(13,13)                                              ONEMG034
C EQUIVALENCE (LG(1,1),GG(1,1)),(LGT(1,1),GGT(1,1))            ONEMG036
C DATA SHMIT(1,1)/0./,TMOLD/0./,TZERO/1965./,NMAX/9/          ONEMG038
C DATA LG / 1, -30339,-1654,1297,958,-223,47,71,10,4*0,5758,-2123,  ONEMG040
A 2994,-2036,805,357,60,-54,9,4*0,-2006,130,1567,1289,492,246,4,0, ONEMG042
B -3,4*0,-403,242,-176,843,-392,-26,-229,12,-12,4*0,149,-280,8,-265ONEMG044
C ,256,-161,3,-25,-4,4*0,16,125,-123,-107,77,-51,-4,-9,7,4*0,-14, ONEMG046
D 106,68,-32,-10,-13,-112,13,-5,4*0,-57,-27,-8,9,23,-19,-17,-2,12, ONEMG048
E 4*0,3,-13,5,-17,4,22,-3,-16,6,56*0/                         ONEMG050
C DATA LGT / 10, 153,-244,2,-7,19,-1,-5,1,4*0,-23,87,3,-108,2,11,-3,ONEMG052
F -3,4,4*0,-118,-167,-16,7,-30,29,11,-7,6,4*0,42,7,-77,-38,-1,6,19,ONEMG054
G -5,5*0,-1,16,29,-42,-21,0,-4,3,5*0,23,17,-24,8,-3,13,-4,0,-1,4*0,ONEMG056
H -9,-4,20,-11,1,9,-2,-2,3,4*0,-11,3,4,2,4,2,3,-6,-3,4*0,1,-2,-3,-2,ONEMG058
I -3,-4,-3,-3,-5,56*0/                                         ONEMG060
C
C DIMENSION CONST(13,13),FN(13),FM(13)                          ONEMG062
C DIMENSION P(13,13),DP(13,13),SP(13),CP(13)                    ONEMG064
C DATA P(1,1),CP(1),DP(1,1),SP(1) / 2*1.,2*0. /
C IF(SHMIT(1,1).EQ.-1.) GO TO 8                                 ONEMG066
C ***** INITIALIZE * ONCE ONLY, FIRST TIME SUBROUTINE IS CALLED ONEMG068
C SHMIT(1,1)=-1.                                                 ONEMG070
C DO 18 N=1,13                                                 ONEMG072
C FN(N)=N                                                       ONEMG074
C DO 18 M=1,13                                                 ONEMG076
C FM(M)=M-1                                                   ONEMG078
C
18 CONST(N,M) = FLOAT((N-2)**2-(M-1)**2) / ((2*N-3)*(2*N-5))  ONEMG080
C DO 2 N=2,13                                                 ONEMG082
C SHMIT(N,1) = (2*N-3) * SHMIT(N-1,1) / (N-1)                ONEMG084
JJ=2
C DO 2 M=2,N                                                 ONEMG086
C SHMIT(N,M) = SHMIT(N,M-1) * SQRT(FLOAT((N-M+1)*JJ)/(N+M-2)) ONEMG088
C SHMIT(M-1,N)=SHMIT(N,M)                                     ONEMG090
C
2 JJ = 1                                                       ONEMG092
F1 = LG(1,1)                                                 ONEMG094
F2 = LGT(1,1)                                                ONEMG096
DO 7 N=1,NMAX                                               ONEMG098
DO 7 M=1,NMAX                                               ONEMG100
GG(N,M) = LG(N,M)*SHMIT(N,M)/F1                           ONEMG102
C
7 GGT(N,M) = LGT(N,M)*SHMIT(N,M)/F2                         ONEMG104
C
8 IF(TM.EQ.TMOLD) GO TO 11                                  ONEMG106
TMOLD=TM
T = TM - TZERO
DO 10 N=1,NMAX
DO 10 M=1,NMAX
10 G(N,M) = GG(N,M) + T*GGT(N,M)                            ONEMG108
C

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C **** STANDARD CALLING ROUTINE FOR GDALMG          002
C **** SINGLE PRECISION DECK FOR IBM 360 MACHINES (EBCDIC, 029 PUNCH) 004
C **** NEEDS SINGLE-PRECISION SUBROUTINES GDALMG AND ALLMAG      006
> REAL*4 TM(2)/1965.,1970./,GDLAT(2)/-30.,60./,GLON(2)/-90.,90./,
1 ALT/100./
PRINT 10
10 FORMAT(*1 MODEL      TIME      LAT      LONG      ALT      X      Y
1       Z           F           H           DEC      INC')
DO 20 MODEL=1,7
DO 20 I=1,2
DO 20 J=1,2
DO 20 K=1,2
CALL GDALMG(MODEL,TM(I),GDLAT(J),GLON(K),ALT,X,Y,Z,F,H,DEC,AINC)
20 PRINT 30,    MODEL,TM(I),GDLAT(J),GLON(K),ALT,X,Y,Z,F,H,DEC,AINC
30 FORMAT(I5,3X,4F8.0,5F10.5,2F10.2)
STOP
END

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0017 CARDS

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C ***** MAIN DECK FOR LINTRA LINTR002
C ***** MODIFIED FIELD LINE TRACING ROUTINE AS OF JAN 1971, LINTR004
C ***** DESIGNED AND TESTED BY E G STASSINOPoulos AND G D MEAD, LINTR006
C ***** CODE 641, NASA GODDARD SPACE FLT CTR, GREENBELT, MD 20771 LINTR008
C ***** SINGLE PRECISION DECK FOR IBM 360 MACHINES (EBCDIC, 029 PUNCH)LINTR010
C ***** NEEDS SINGLE-PRECISION SUBROUTINES CONVRT, ITERAT, AND ALLMAG.LINTR012
C ***** ACCEPTING INPUT COORDINATES OF STARTING POINTS IN EITHER A LINTR014
C ***** GEOCENTRIC OR GEODETIC SYSTEM AND RETURNING COORDINATES LINTR016
C ***** FOR CONJUGATE INTERSECT POSITIONS IN BOTH SYSTEMS. LINTR018
C ***** INTERSECTS MAY BE OBTAINED AT ANY SPECIFIED ALTITUDE LEVEL. LINTR020
C ***** DIRECTION OF TRACING INPUT-CONTROLLED THROUGH PARAMETER "DIR".LINTR022
C ***** FOR SURFACE POINTS "DIR" SHOULD ALWAYS BE (+1). LINTR024
C ***** FOR SPACE POINTS, (DIR>0) WILL TRACE THE FIELD LINE TO THE LINTR026
C ***** OPPOSITE HEMISPHERE, (DIR<0) WILL TRACE THE FIELD LINE TOWARDSLINTR028
C ***** THE SURFACE IN THE SAME HEMISPHERE. LINTR030
C ***** INPUT: MODEL CHOICE OF 7 MODELS (FROM ALLMAG) LINTR032
C ***** TM TIME IN YEARS FOR DESIRED FIELD LINTR034
C ***** NPRINT PARAMETER CONTROLLING OUTPUT LINTR036
C ***** =0 NO RUNNING PRINTOUT; =1 PRINT STEPS LINTR038
C ***** ICOORD REFERENCE SYSTEM OF INPUT COORDINATES LINTR040
C ***** =1 GEODETIC; =2 GEOCENTRIC LINTR042
C ***** GDLAT,GLON,ALT GEODETIC STARTING POINT COORD(DEGR.,KM) LINTR044
C ***** GCLAT,GLON,RKM GEOCENTRIC STARTING POINT COORD( " , " )LINTR046
C ***** DS TRACING STEPSIZE IN KILOMETERS LINTR048
C ***** DIR PARAMETER CONTROLLING DIRECTION OF TRACELINTR050
C ***** +1. STARTS TRACING TOWARDS HIGHER ALT. LINTR052
C ***** -1. STARTS TRACING TOWARDS LOWER ALT. LINTR054
C ***** HALT GEODETIC ALTITUDE OF CONJUGATE INTERSECTLINTR056
C ***** LABEL NAME OF ORIGIN (STARTING POINT) LINTR058
C ***** OUTPUT: PLAT,PLON,PRKM GEOCENTRIC COORD. OF CONJUGATE INTERSECTLINTR060
C ***** PGLAT,PLON,PALT GEODETIC COORD. OF CONJUGATE INTERSECT LINTR062
C ***** ARC ARCLENGTH OF FIELD LINE TRACED, IN KM LINTR064
C ***** BMIN MINIMUM FIELD STRENGTH ALONG LINE LINTR066
C ***** BMINLT,BMINLN, GEOCENTRIC COORD. OF BMIN POSITION, IN LINTR068
C ***** BMINR DEGREES AND KILOMETERS LINTR070
COMMON /ITER/ L,R,DLAT,DLON,RP,DLATP,DLONP,BR,BT,BP,B,ST,SGN,DS LINTR072
DATA RAD/57.2957795/, C1/.0067397/, RA/6378.16/, MAXS/200/ LINTR074
10 FORMAT(6F10.6,2A4) LINTR076
11 FORMAT('0',47X,'STEP',7X,'LAT',5X,'LON',4X,'RKM',3X,'ALT',7X,'BR',LINTR078
   16X,'BT',6X,'BP',7X,'B',/) LINTR080
12 FORMAT(20X,'OLD COORDINATES FOR STEP#',I6,' **',2F9.3,2F8.0,4F9.5)LINTR082
13 FORMAT('1MODEL ',I8,', TIME ',F9.2/, ' PRINT ',I8,', COORD ',I8,/) LINTR084
14 FORMAT(10X,'GEOCENTRIC COORDINATES GEODETIC COORDINATES STEPLINTR086
   1SIZE/ARCLENGTH DIR HALT LABEL',/,12X,'LAT LONG RKM', LINTR088
   27X,'LAT LONG ALT',9X,'DS/ARC',/,11X,'(DEGR) (DEGR) (KM)', LINTR090
   36X,'(DEGR) (KM)',9X,'(KM)',/) LINTR092
15 FORMAT(' ORIGIN ',2F8.2,F8.1,1X2F8.2,F8.1,F11.0,9X,2F7.0,5X,2A4) LINTR094
16 FORMAT(I5,F10.2,2I5) LINTR096
17 FORMAT('0INTRSCT ',F6.2,F8.2,F8.1,1X,2F8.2,F8.1,F11.0,////) LINTR098
18 FORMAT(' CHECK INPUT: ALT=',F8.0,9X,'DIR=',F3.0,9X,'HALT=',F8.0//)LINTR100
19 FORMAT('0LINE TRACING TERMINATED: ITERATION EXCEEDS 200 STEPS',//)LINTR102
PINTER(A1,A2,A3,A4,A5,A6,A7) = ((A2-A3)*(A7-A2)*(A7-A3)*A4-(A1-A3)LINTR104
1 *(A7-A1)*(A7-A3)*A5+(A1-A2)*(A7-A1)*(A7-A2)*A6)/((A1-A2)*(A1-A3) LINTR106
2 *(A2-A3)) LINTR108
READ(5,16,END=6) MODEL,TM,NPRINT,ICOORD LINTR110
WRITE(6,13) MODEL,TM,NPRINT,ICOORD LINTR112
IF(NPRINT.EQ.0) WRITE(6,14) LINTR114
IF(ICOORD.EQ.2) GO TO 2 LINTR116
1 READ(5,10,END=6) GDLAT,GLON,ALT,DS,DIR,HALT,LABEL1,LABEL2 LINTR118
CALL CONVRT(1,GDLAT,ALT,GCLAT,RKM) LINTR120

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SUBROUTINE ITERAT                                ITRAT002
C*** SINGLE PRECISION DECK FOR IBM 360 MACHINES (EBCDIC, 029 PUNCH)   ITRAT004
C*** FIELD LINE INTEGRATION PROGRAM USING A 4-POINT ADAMS FORMULA AFTERITRAT006
C*** INITIALIZATION. FIRST 7 ITERATIONS ADVANCE POINT BY 3*DS      ITRAT008
C*** INPUT: L           STEP COUNT. SET L=1 FIRST TIME THRU; ITRAT010
C***                      SET L=L+1 THEREAFTER.                   ITRAT012
C***          Y(1-3): R,DLAT,DLON    GEOCENTR TRACING POINT COORD.(KM,DEGR) ITRAT014
C***          B,BR,BT,BP        FIELD & COMPONENTS AT POINT Y(1-3)     ITRAT016
C***          ST              SINE OF GEOCENTRIC COLATITUDE       ITRAT018
C***          SGN             SGN=+1: TRACES IN DIRECTION OF FIELD ITRAT020
C***                      SGN=-1: TRACES OPPOSITE TO FIELD DIRECITRAT022
C***          DS              INTERGR. STEPSIZE (ARC INCREMENT) IN KM ITRAT024
C***OUTPUT: Y(1-3): R,DLAT,DLON    NEW IMPLEMENTED TRACING POINT COORD   ITRAT026
C***          YOLD(1-3): RP,DLATP,DLONP OLD Y(1-3), BEFORE IMPLEMENTATION ITRAT028
COMMON /ITER/ L,Y,YOLD,BR,BT,BP,B,ST,SGN,DS      ITRAT030
DIMENSION Y(3),YOLD(3),YP(3,4)                    ITRAT032
DATA RAD /57.2957795/                            ITRAT034
YP(1,4)=SGN*(BR/B)                               ITRAT036
FAC=SGN*RAD/(B*Y(1))                           ITRAT038
YP(2,4)=-BT*FAC                                 ITRAT040
YP(3,4)=BP*FAC/ST                               ITRAT042
IF(L.GT.7) GO TO 9                               ITRAT044
DO 8 I=1,3                                       ITRAT046
GO TO(1,2,3,4,5,6,7),L                          ITRAT048
1 D2=DS/2.                                       ITRAT050
D6=DS/6.                                         ITRAT052
D12=DS/12.                                        ITRAT054
D24=DS/24.                                        ITRAT056
YP(I,1) = YP(I,4)                               ITRAT058
YOLD(I) = Y(I)                                   ITRAT060
Y(I) = YOLD(I) + DS* YP(I,1)                     ITRAT062
GO TO 8                                         ITRAT064
2 YP(I,2) = YP(I,4)                               ITRAT066
Y(I) = YOLD(I) + D2 * (YP(I,2) + YP(I,1))       ITRAT068
GO TO 8                                         ITRAT070
3 Y(I) = YOLD(I) + D6 * (2.*YP(I,4) + YP(I,2) + 3.*YP(I,1)) ITRAT072
GO TO 8                                         ITRAT074
4 YP(I,2) = YP(I,4)                               ITRAT076
YOLD(I) = Y(I)                                   ITRAT078
Y(I) = YOLD(I) + D2 * (3.*YP(I,2) - YP(I,1))       ITRAT080
GO TO 8                                         ITRAT082
5 Y(I) = YOLD(I) + D12 * (5.*YP(I,4) + 8.*YP(I,2) - YP(I,1)) ITRAT084
GO TO 8                                         ITRAT086
6 YP(I,3) = YP(I,4)                               ITRAT088
YOLD(I) = Y(I)                                   ITRAT090
Y(I) = YOLD(I) + D12 * (23.*YP(I,3) - 16.*YP(I,2) + 5.*YP(I,1)) ITRAT092
GO TO 8                                         ITRAT094
7 Y(I)=YOLD(I)+D24*(9.*YP(I,4)+19.*YP(I,3)-5.*YP(I,2)+YP(I,1)) ITRAT096
8 CONTINUE                                         ITRAT098
RETURN                                            ITRAT100
9 DO 10 I=1,3                                     ITRAT102
YOLD(I) = Y(I)                                   ITRAT104
Y(I)=YOLD(I)+D24*(55.*YP(I,4)-59.*YP(I,3)+37.*YP(I,2)-9.*YP(I,1)) ITRAT106
DO 10 J=1,3                                     ITRAT108
10 YP(I,J) = YP(I,J+1)                         ITRAT110
RETURN                                            ITRAT112
END                                              ITRAT114

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0057 CARDS

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C *** MAIN FOR INVARA USING ALLMAG AND THE COORDINATE CONVERSION      002
C *** DOUBLE PRECISION DECK FOR IBM 360 MACHINES (EBCDIC, 029 PUNCH)    004
C *** INPUT:                                                               006
C ***           ICOORD        REFERENCE SYSTEM OF INPUT COORDINATES     008
C ***                               =1 GEODETIC; =2 GEOCENTRIC.                010
C ***           MODEL         CHOICE OF 7 MODELS (FROM ALLMAG)          012
C ***           TM            TIME IN YEARS FOR DESIRED FIELD          014
C
IMPLICIT REAL*8 (A-H,O-Z)
DATA RAD/57.2957795/
1 FORMAT('0',9X,'GEOCENTRIC COORDINATES      GEODETIC COORDINATES',020
1 10X,'B',14X,'L',/,11X,'LAT    LONG    ALT',7X,'LAT    LONG',022
2 4X,'ALT',/,10X,'(DEGR) (DEGR) (KM)',6X,'(DEGR) (DEGR) (KM)',024
3 9X,'(GAUSS)',6X,'(EARTH RADII)')026
2 FORMAT(2I5,F10.3)028
3 FORMAT('0',7X,2F8.2,F8.1,1X,2F8.2,F8.1,2X,F12.5,F12.4)030
4 FORMAT(3F10.3)032
5 FORMAT('1  MODEL',I3,/,,' TIME',F8.1,/,,' ICOORD',I3)034
READ(5,2) ICOORD,MODEL,TM036
WRITE(6,5) MODEL,TM,ICOORD038
WRITE(6,1)040
IF(ICOORD.EQ.2) GO TO 8042
7 READ(5,4,END=99) GDLAT,GLON,GDLAT044
CALL CONVRT(1,GDLAT,GDLAT,GCLAT,RKM)046
CT=DSIN(GCLAT/RAD)048
GCALT=RKM-6378.16/DSQRT(1.+0.0067397*CT*CT)050
GO TO 9052
8 READ(5,4,END=99) GCLAT,GLON,GCALT054
CT=DSIN(GCLAT/RAD)056
RKM=GCALT+6378.16/DSQRT(1.+0.0067397*CT*CT)058
CALL CONVRT(2,GDLAT,GDLAT,GCLAT,RKM)060
9 CALL INVARA(MODEL,TM,GCLAT,GLON,GCALT,0.01D0,BB,FL)062
WRITE(6,3) GCLAT,GLON,GCALT,GDLAT,GLON,GDLAT,BB,FL064
GO TO (7,8),ICOORD066
99 STOP068
END070
2   1  1965.0
50.000  60.000  1000.000
30.000  60.000  1000.000
10.000  60.000  1000.000
-10.000  60.000  1000.000
-30.000  60.000  1000.000
-50.000  60.000  1000.000
50.000  160.000 1000.000
30.000  160.000 1000.000
10.000  160.000 1000.000
-10.000  160.000 1000.000
-30.000  160.000 1000.000
-50.000  160.000 1000.000
50.000  260.000 1000.000
30.000  260.000 1000.000
10.000  260.000 1000.000
-10.000  260.000 1000.000
-30.000  260.000 1000.000
-50.000  260.000 1000.000
50.000  360.000 1000.000
30.000  360.000 1000.000
-10.000  360.000 1000.000
-30.000  360.000 1000.000
-50.000  360.000 1000.000
10.000  360.000 1000.000

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Input data used in INVARA
test run, chosen to be
compatible with Table II-2
in Hassitt & McIlwain (1967)

50.000 60.000 1000.000
30.000 60.000 1000.000
10.000 60.000 1000.000
-10.000 60.000 1000.000
-30.000 60.000 1000.000
-50.000 60.000 1000.000
50.000 160.000 1000.000
30.000 160.000 1000.000
10.000 160.000 1000.000
-10.000 160.000 1000.000
-30.000 160.000 1000.000
-50.000 160.000 1000.000
50.000 260.000 1000.000
30.000 260.000 1000.000
10.000 260.000 1000.000
-10.000 260.000 1000.000
-30.000 260.000 1000.000
-50.000 260.000 1000.000
50.000 360.000 1000.000
30.000 360.000 1000.000
-10.000 360.000 1000.000
-30.000 360.000 1000.000
-50.000 360.000 1000.000
10.000 360.000 1000.000

NASA-GSFC COML., Arlington, Va.

MODEL 1
TIME 1965.00
PRINT 1
COORD 1

OUTPUT FROM LINTRA TEST RUN #1 (IPRINT = 1)

GEODETIC COORDINATES			GEOCENTRIC COORDINATES			STEP SIZE/ARC LENGTH DS/ARC (KM)	DIR	HALT	LABEL		
LAT (DEGR)	LONG (DEGR)	RKM (KM)	LAT (DEGR)	LONG (DEGR)	ALT (KM)						
ORIGIN 44.81	-90.00	6367.5	45.00	-90.00	0.0	811.	1.	0.	TEST 1		
			STEP	LAT	LONG	RKM	ALT	BR	BT	BP	B

MODEL USED IS NUMBER 1 HENDRICKS&CAIN 99-TERM GSFC 9/65 FOR TM = 1965.000

OLD COORDINATES FOR STEP# 1 ** 44.808 -90.000 6368.	-0. -0.57342 -0.15686 0.00830 0.59455
OLD COORDINATES FOR STEP# 2 ** 44.808 -90.000 6368.	-1. -0.38375 -0.12143 0.00732 0.40257
OLD COORDINATES FOR STEP# 3 ** 44.808 -90.000 6368.	-1. -0.38448 -0.12173 0.00736 0.40335
OLD COORDINATES FOR STEP# 4 ** 42.865 -90.153 7145.	777. -0.38448 -0.12173 0.00736 0.40335
OLD COORDINATES FOR STEP# 5 ** 42.865 -90.153 7145.	776. -0.27011 -0.09618 0.00616 0.28679
OLD COORDINATES FOR STEP# 6 ** 40.897 -90.318 7913.	1544. -0.27016 -0.09614 0.00615 0.28682
OLD COORDINATES FOR STEP# 7 ** 40.897 -90.318 7913.	1543. -0.19673 -0.07724 0.00510 0.21142
OLD COORDINATES FOR STEP# 8 ** 38.934 -90.484 8672.	2302. -0.19671 -0.07724 0.00510 0.21141
OLD COORDINATES FOR STEP# 9 ** 36.980 -90.652 9421.	3051. -0.14729 -0.06319 0.00427 0.16033
OLD COORDINATES FOR STEP# 10 ** 35.043 -90.816 10161.	3790. -0.11281 -0.05247 0.00362 0.12447
OLD COORDINATES FOR STEP# 11 ** 33.124 -90.978 10891.	4519. -0.08803 -0.04417 0.00311 0.09854
OLD COORDINATES FOR STEP# 12 ** 31.218 -91.138 11609.	5237. -0.06977 -0.03766 0.00270 0.07932
OLD COORDINATES FOR STEP# 13 ** 29.323 -91.297 12316.	5943. -0.05602 -0.03247 0.00237 0.06479
OLD COORDINATES FOR STEP# 14 ** 27.437 -91.455 13011.	6637. -0.04549 -0.02826 0.00210 0.05360
OLD COORDINATES FOR STEP# 15 ** 25.555 -91.613 13692.	7318. -0.03728 -0.02487 0.00188 0.04485
OLD COORDINATES FOR STEP# 16 ** 23.674 -91.770 14356.	7983. -0.03080 -0.02206 0.00170 0.03792
OLD COORDINATES FOR STEP# 17 ** 21.791 -91.929 15008.	8633. -0.02562 -0.01972 0.00154 0.03236
OLD COORDINATES FOR STEP# 18 ** 19.901 -92.088 15641.	9265. -0.02142 -0.01777 0.00141 0.02786
OLD COORDINATES FOR STEP# 19 ** 18.003 -92.249 16254.	9878. -0.01799 -0.01612 0.00130 0.02419
OLD COORDINATES FOR STEP# 20 ** 16.092 -92.411 16846.	10469. -0.01516 -0.01472 0.00121 0.02116
OLD COORDINATES FOR STEP# 21 ** 14.163 -92.576 17414.	11038. -0.01279 -0.01353 0.00113 0.01865
OLD COORDINATES FOR STEP# 22 ** 12.222 -92.743 17957.	11580. -0.01081 -0.01252 0.00106 0.01657
OLD COORDINATES FOR STEP# 23 ** 10.257 -92.914 18471.	12093. -0.00912 -0.01165 0.00100 0.01483
OLD COORDINATES FOR STEP# 24 ** 8.270 -93.088 18953.	12575. -0.00768 -0.01091 0.00095 0.01338
OLD COORDINATES FOR STEP# 25 ** 6.258 -93.257 19400.	13022. -0.00643 -0.01029 0.00091 0.01216
OLD COORDINATES FOR STEP# 26 ** 4.221 -93.450 19809.	13431. -0.00554 -0.00975 0.00088 0.01116
OLD COORDINATES FOR STEP# 27 ** 2.158 -93.639 20175.	13977. -0.00438 -0.00931 0.00086 0.01032
OLD COORDINATES FOR STEP# 28 ** 0.070 -93.834 20496.	14118. -0.00352 -0.00894 0.00084 0.00964
OLD COORDINATES FOR STEP# 29 ** -2.041 -94.034 20767.	14388. -0.00275 -0.00864 0.00083 0.00911
OLD COORDINATES FOR STEP# 30 ** -4.171 -94.242 20984.	14606. -0.00203 -0.00841 0.00083 0.00869
OLD COORDINATES FOR STEP# 31 ** -6.323 -94.457 21145.	14767. -0.00136 -0.00824 0.00083 0.00840
OLD COORDINATES FOR STEP# 32 ** -8.485 -94.679 21247.	14869. -0.00073 -0.00814 0.00084 0.00821
OLD COORDINATES FOR STEP# 33 ** -10.653 -94.909 21288.	14910. -0.00011 -0.00809 0.00086 0.00816
OLD COORDINATES FOR STEP# 34 ** -12.823 -95.147 21268.	14961. -0.00051 -0.00975 0.00088 0.01116
OLD COORDINATES FOR STEP# 35 ** -14.985 -95.394 21187.	15187. -0.00051 -0.00810 0.00088 0.00817
OLD COORDINATES FOR STEP# 36 ** -17.136 -95.650 21046.	15467. -0.00179 -0.00830 0.00096 0.00856
OLD COORDINATES FOR STEP# 37 ** -19.270 -95.916 20846.	15846. -0.00248 -0.00849 0.00102 0.00890
OLD COORDINATES FOR STEP# 38 ** -21.383 -96.192 20596.	16221. -0.00322 -0.00874 0.00109 0.00938
OLD COORDINATES FOR STEP# 39 ** -23.473 -96.480 20293.	16793. -0.00403 -0.00906 0.00117 0.00998
OLD COORDINATES FOR STEP# 40 ** -25.573 -96.779 19943.	17369. -0.00493 -0.00945 0.00127 0.01074
OLD COORDINATES FOR STEP# 41 ** -27.572 -97.093 19549.	17949. -0.00559 -0.00992 0.00140 0.01165
OLD COORDINATES FOR STEP# 42 ** -29.582 -97.422 19116.	18523. -0.00711 -0.01047 0.00154 0.01275
OLD COORDINATES FOR STEP# 43 ** -31.565 -97.769 18647.	19275. -0.00843 -0.01113 0.00172 0.01407
OLD COORDINATES FOR STEP# 44 ** -33.523 -98.137 18145.	19774. -0.00998 -0.01189 0.00193 0.01564
OLD COORDINATES FOR STEP# 45 ** -35.458 -98.527 17614.	20243. -0.01178 -0.01279 0.00218 0.01752
OLD COORDINATES FOR STEP# 46 ** -37.373 -98.945 17056.	20686. -0.01391 -0.01383 0.00250 0.01977
OLD COORDINATES FOR STEP# 47 ** -39.269 -99.394 16474.	21105. -0.01644 -0.01505 0.00288 0.02248
OLD COORDINATES FOR STEP# 48 ** -41.149 -99.880 15871.	21502. -0.01949 -0.01648 0.00336 0.02575
OLD COORDINATES FOR STEP# 49 ** -43.017 -100.409 15248.	21879. -0.02319 -0.01817 0.00395 0.02972
OLD COORDINATES FOR STEP# 50 ** -44.875 -100.990 14607.	2239. -0.02771 -0.02017 0.00471 0.03459
OLD COORDINATES FOR STEP# 51 ** -46.726 -101.633 13949.	2583. -0.03331 -0.02255 0.00567 0.04062
OLD COORDINATES FOR STEP# 52 ** -48.572 -102.352 13278.	2911. -0.04032 -0.02540 0.00694 0.04815
OLD COORDINATES FOR STEP# 53 ** -50.417 -103.162 12592.	3227. -0.04920 -0.02886 0.00860 0.05769
OLD COORDINATES FOR STEP# 54 ** -52.264 -104.086 11895.	3530. -0.05664 -0.03309 0.01085 0.06993
OLD COORDINATES FOR STEP# 55 ** -54.114 -105.152 11187.	3823. -0.07560 -0.03831 0.01395 0.08589
OLD COORDINATES FOR STEP# 56 ** -55.968 -106.399 10468.	4105. -0.09555 -0.04484 0.01830 0.10712
OLD COORDINATES FOR STEP# 57 ** -57.828 -107.878 9741.	3378. -0.12275 -0.05311 0.02461 0.13600
OLD COORDINATES FOR STEP# 58 ** -59.692 -109.663 9005.	2643. -0.16088 -0.06373 0.03400 0.17635
OLD COORDINATES FOR STEP# 59 ** -61.555 -111.853 8262.	1900. -0.21611 -0.07753 0.04849 0.23466
OLD COORDINATES FOR STEP# 60 ** -63.404 -114.587 7512.	1151. -0.29962 -0.09570 0.07166 0.32259
OLD COORDINATES FOR STEP# 61 ** -65.216 -118.053 6756.	396. -0.43309 -0.11978 0.11018 0.46266

INTRSCT -66.13 -120.24 6360.3 -66.27 -120.24 0.0 45819.

MODEL 1
TIME 1965.00
PRINT 0
COORD 1

OUTPUT FROM LINTRA TEST RUN #2 (IPRINT = 0)

GEODETIC COORDINATES			GEOCENTRIC COORDINATES			STEP SIZE/ARC LENGTH DS/ARC (KM)	DIR	HALT	LABEL
LAT (DEGR)	LONG (DEGR)	RKM (KM)	LAT (DEGR)	LONG (DEGR)	ALT (KM)				
ORIGIN 74.90	0.0	6358.2	75.00	0.0	0.0	3000.	1.	0.	TEST RUN

MODEL USED IS NUMBER 1 HENDRICKS&CAIN 99-TERM GSFC 9/65 FOR TM = 1965.000

INTRSCT -67.89 73.66 6359.8 -68.02 73.66 0.0 201132.

ORIGIN 44.81 -90.00 6367.5 45.00 -90.00 0.0 811. 1. 0. TEST RUN

INTRSCT -66.13 -120.24 6360.3 -66.27 -120.24 0.0 45819.

ORIGIN -44.81 90.00 6367.5 -45.00 90.00 0.0 811. 1. 0. TEST RUN

INTRSCT 62.36 75.65 6361.4 62.52 75.65 0.0 46710.

ORIGIN -74.90 0.0 6358.2 -75.00 0.0 0.0 2364. 1. 0. TEST RUN

INTRSCT 55.69 -45.58 6363.5 55.87 -45.58 0.0 73649.



5

6



7

8

